INTAKE ASSESSMENT OF POLYBROMINATED FLAME RETARDANTS BY SEAFOOD CONSUMPTION

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Introduction

Flame retardants (FRs) are additives applied since the seventies in a lot of different consumer products. Different chemical formulations with flame retardant characteristics exist, divided into five different groups: inorganic, halogenated organic, organophosphorus and nitrogen-based compounds and mixtures[1].

Polybrominated diphenyl ethers (PBDEs) belong to the group of halogenated organic FRs, apart from tetrabromobisphenol A and hexabromocyclododecane. In this abstract we focus on the PBDEs. PBDEs are highly lipophilic contaminants, present in the environment and bioaccumulating in the human food chain. Since the world-wide use of PBDEs, these contaminants are now ubiquitous in the environment.

For humans, diet appears to be the major source of exposure to these brominated contaminants[1,2]. Since PBDEs are widely distributed in seafood, this study focuses on this group of food items as PBDEs exposure route for humans. An intake assessment of these contaminants is executed for a subgroup of the Belgian population in order to explore the risk related to the consumption of seafood, which is on the other hand an important source of long chain omega-3 fatty acids, related with a lot of beneficial health aspects. The intake assessment is not based on own analytical data of PBDEs in seafood, but it is executed on the basis of publicly available contamination data. This is in accordance with the strategy recently proposed by Brüders et al.[3], stating that existing data should be used in the most effective way as collecting samples and analysing them is expensive.

Materials and Methods

An Excel®-database has been constituted with regard to the PBDE concentrations in seafood. In the database, all relevant information is included: commercial name, scientific name, period of capture, number of samples, number of individuals per sample in the case of pooled samples, fat content of the fish and (mean) contaminant content, if available with extra statistical data (standard deviation, minimum and maximum). Concentration data were filled out per individual PBDE congener. Since the data about seafood consumption are expressed in g wet weight/day/individual and since the percentage of available data expressed in ng/g wet weight was higher than that of data expressed in ng/g lipid weight, the latter were converted to ng/g wet weight if the fat content of the analysed sample was known. The methodology applied to construct this database was based on a previously developed methodology for the construction of databases for other contaminants[4]. Afterwards, the data were filtered to end up with those species relevant for the Belgian consumer. On the basis of data about the origin of fish on the Belgian market, a second selection was made.

For the intake assessment, food consumption data were used, based on a 7 day estimated food record (341 boys and girls between 13 and 18 years old)[5]. Data were collected in Ghent (Belgium) between March and May 1997. The intake of PBDEs is assessed on the basis of seafood consumption only (no other food items are taken into consideration).

To calculate the intake, the following model was applied, combining seafood consumption data with contaminant concentrations:

$$Y_i = \frac{\sum_v \sum_t (X_{v,i,t} \cdot C_v)}{T \cdot BW_i}$$

where Y_i= average daily intake of subject i; $X_{v,i,t}$= amount (g) of fish v consumed by subject i (with body weight BW_i), at day t ($t = 1,\ldots,T$); and C_v= concentration of a specific nutrient/contaminant in fish v. The intakes were assessed using a probabilistic approach, with a so called one-dimensional Monte Carlo simulation programme that takes the variability of the food consumption data, the body weight data and the PBDE concentration data into account. During each sampling out of the available data, intake data from the subjects are being linked to concentration data, thereby generating series of theoretically occurring PBDE intakes on individual level. These calculations were done using the Hexalog software (Aardex Ltd.).

Results and Discussion

At the end of May 2006, the database contained data from 30 different international publications and two databases (Nifes[6] and Canada Health[7]). All of them were found using the following resources: PubMed, Web of Science and Google. An analysis was made to determine which of the 209 existing PBDE-congeners were described most abundantly. For different species, data were available for BDE-28, 47, 99, 100, 153 and 154, as well as for BDE-183 and 209. But only for congener BDE-47, 99 and 100 enough data were available for the different relevant seafood species in order to execute a probabilistic intake assessment. So the intake assessment has focussed on these three PBDE congeners only.

On the basis of the fish species mentioned in the food consumption database of the adolescents, 34 different seafood species were considered. PBDE concentration data about 25 of these 34 seafood species were available in the newly compiled database. This indicates that representative data describing the PBDE concentration in seafood species relevant for Belgian consumption are rather scarce. This leads to the fact that data had to be grouped according to their fat content and that the intake assessment is focussed on only three congeners. Five fat groups (FG) were determined in order to group the species as well as their PBDE concentrations according to their fat concentration. The rationale of this was the lipophilic nature of the contaminants. Table 1 gives the number of concentration data available per fat group and per congener.

Table 1 Number of available concentration data (N) for the different congeners and the different species grouped per fat group (FG)

	Description	N(BDE-47)	N(BDE-99)	N(BDE-100)
FG1	<1.0% fat	10	10	10
FG2	1.0% ≤ fat < 2.5%	9	9	9
FG3	2.5% ≤ fat < 5.0%	4	4	4
FG4	5.0% ≤ fat < 10%	10	10	10
FG5	10% ≤ fat	42	40	40

The figures below (figure 1 to 3) show the result of the intake assessment for the three different congeners. The figures show that a large part of the population has a negligible intake of the three contaminant congeners. The main reason therefore is their low consumption of seafood. From the 341 respondents, 123 (36%) did not eat any seafood during the week of the study and as such their calculated contaminant intake was equal to zero.

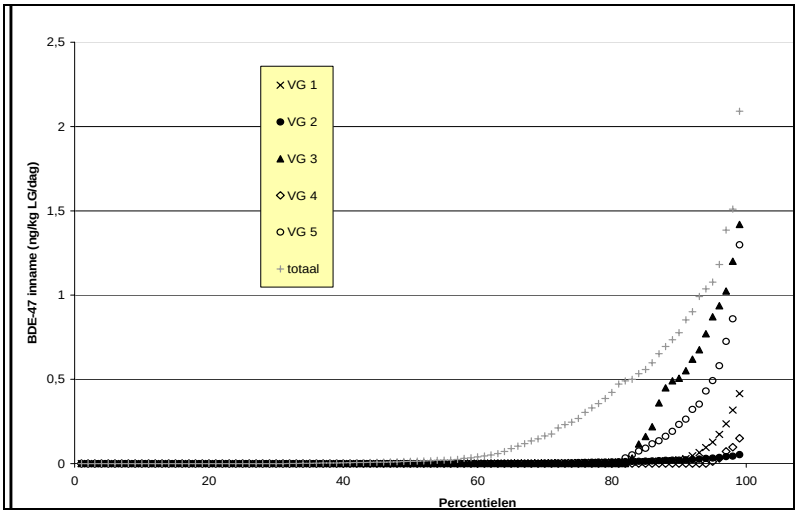

Figure 1 Cumulative probability distribution of the intake of BDE-47 for the study population (in ng/kg bw/day)

Figure 1 shows that fishes from fat group 3 (including species like anchovy, halibut and tuna) contribute most to the intake of BDE-47. The median intake of BDE-47 is 0.013 ng/kg bw/day. At the 75th percentile, the intake is equal to 0.268 ng/kg bw/day and at the 95th percentile 1.078 ng/kg bw/day.

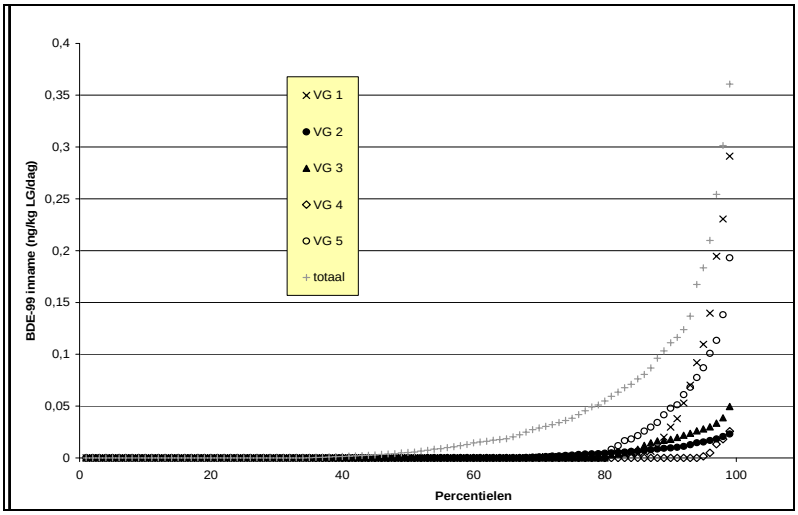

Figure 2 Cumulative probability distribution of the intake of BDE-99 for the study population (in ng/kg bw/day)

Figure 2 shows that both seafood belonging to fat group 1 (lean species like cod, pollack, crab and whiting) and fat group 5 (fatty fishes like salmon, herring, eel and mackerel) contribute most to the intake of BDE-99. The contribution to the intake is determined by the amount of consumption as well as by the degree of contamination. The intake of BDE-99 at the 50th, 75th and 95th percentile is 0.005 ng/kg bw/day, 0.038 ng/kg bw/day and 0.183 ng/kg bw/day, respectively, being almost one order of magnitude smaller than the assessed intake of BDE-47.

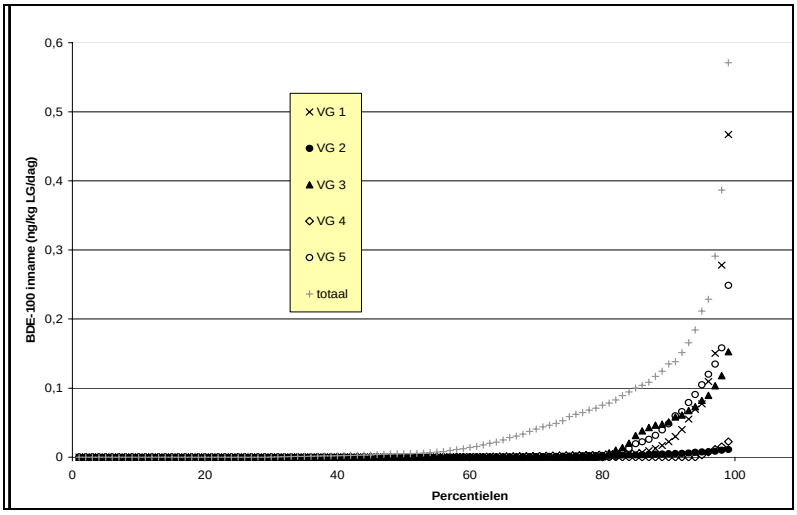

Figure 3 Cumulative probability distribution of the intake of BDE-100 for the study population (in ng/kg bw/day)

Species belonging to fat group 2 and 4 have almost no contribution to the intake of BDE-100. The intake of BDE-100 at the 50th, 75th and 95th percentile is of the same order of magnitude compared with BDE-99, respectively 0.005 ng/kg bw/day, 0.058 ng/kg bw/day and 0.211 ng/kg bw/day. The higher intake of BDE-47 compared to BDE-99 and BDE-100 is in accordance with literature data[8,9,10].

Our calculated data are in line with the results of a probabilistic intake assessment executed in the Netherlands. They calculated a 50th percentile of intake of the sum of BDE congeners in the total Dutch population equal to 1.71 ng/kg bw/day, on the basis of the total diet, with oils and fats, milk and fish being the most important sources[10].

In conclusion, an attempt was made to calculate the intake of PBDEs via seafood consumption on the basis of publicly available data. Nevertheless, such data are rather scarce. In order to reduce the uncertainty in the estimate of the dietary intake of PBDEs, more data about measured concentrations are needed. The results

presented in this abstract show that most data are available about BDE-47, 99 and 100, with BDE-47 contributing most to the intake via seafood consumption.

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